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TECHNICAL REPORT NO. 11741

PERFORMANCE STANDARDS AND SPECIFICATIONS FOR AUTOMOTIVE BRAKES

January 1973

by JOSEPH J. MIKAILA

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VEHICULAR COMPONENTS & MATERIALS LABORATORY
U.S. ARMY TANK AUTOMOTIVE COMMAND Warren, Michigan

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PERFORMANCE STANDARDS AND SPECIFICATIONS
FOR AUTOMOTIVE BRAKES

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US ARMY TANK-AUTOMOTIVE COMMAND
RESEARCH, DEVELOPMENT AND ENGINEERING DIRECTORATE
VEHICULAR COMPONENTS AND MATERIALS DIVISION
AUTOMOTIVE COMPONENTS BRANCH
MECHANICAL FUNCTION

ACKNOWLEDGEMENT

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ABSTRACT

This is a report of an effort to develop a laboratory test procedure for measuring the performance of a brake assembly and individual components on a brake dynamometer. This report presents a test procedure that measures brake retarding torque vs temperature, brake retarding torque vs speed, brake lining wear rate and moisture sensitivity.

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INTRODUCTION

The need for performance standards and specifications for automotive brakes arises from the fact that currently the only method for evaluating brake linings is through full vehicle tests in accordance with Military Test Procedure 2-2-608.

This is an expensive method costing from $15,000 to $25,000 per test, depending on vehicle size. Previous Federal Specifications for replacement brake lining, such as HH-L-361b, were ineffective because they tested one-inch square samples of brake linings and then categorized the resulting hot and cold friction into four or five categories. The fallacy to this method was the fact that a one-inch square sample does not perform the same as a complete piece of brake lining.

Since vehicle tests are expensive, and the policy of the Department of the Army is to have competitive procurement wherever possible, it was decided to develop a laboratory method which would allow for quick and effective evaluation of brake linings.

OBJECT

Develop a quick, effective and low cost method for defining performance standards and specifications for automotive brakes. The primary use of this test should be to evaluate brake linings, though it should be just as effective for evaluation of brake drums, backing plates and other brake assembly components.

SUMMARY

1. A study was made of the various methods of evaluating brake linings.

2. The inertia dynamometer was chosen as the tool for brake performance evaluation.

3. An inertia dynamometer test procedure was written.

4. A program of both vehicle and dynamometer testing was undertaken. The results of this test program show that the dynamometer test results correlate with vehicle test results.

CONCLUSIONS

The test procedure generated by this program is a valid tool for evaluation of brake assembly components, in particular brake linings. A brake lining that provides "or equal" performance to original equipment (OE) lining on the inertia dynamometer will also perform as well as the OE lining on a vehicle with respect to coefficient of friction, wear and water sensitivity characteristics.

PERFORMANCE PARAMETER SELECTION

To define the performance of a brake lining it was necessary to select performance characteristics which are to be measured. After a literature and brake industry survey, it was decided that the three characteristics that bracket a brake lining performance are:

a. Coefficient of friction vs. temperature and rubbing speed.

b. Wear rate at constant work.

c. Water sensitivity.

EQUIPMENT SELECTION

The four main pieces of laboratory test apparatus for evaluation of brake linings had been previously investigated by the Office of Vehicle Safety Research, National Bureau of Standards. The evaluation of the SAE J661 Friction Machine, the FAST machine, the Girling scale dynamometer and the inertia brake dynamometer showed that only the brake dynamometer test results correlated closely with vehicle performance. The findings are presented in the Bibliography, Item #9.

TEST PROCEDURE DEVELOPMENT

Once the inertia dynamometer was selected as the test apparatus to be used to measure brake lining performance criteria, a survey was made of industrial and government test procedures. There was not too much difference in these test procedures since they all contained the basic requirements for burnishing, effectiveness, fade, recovery and wear. The test procedure that was decided on is shown in the Appendix. It is similar to commercial test procedures with the exception that the details are applicable to peculiarities, such as low top speed, of military vehicles.

TEST PROCEDURE VERIFICATION

A program was undertaken to verify the proposed dynamometer test procedure.

Original equipment and five proposed replacement brake lining materials were tested on a M151-A2 truck and also on a single end inertia dynamometer. The dynamometer was used to determine braking performance of the original equipment brake lining and of the replacement linings for "or equal" evaluation. The cold effectiveness, fade and recovery, water recovery and wear properties of the materials were used to establish the relative performance. Vehicle road tests used a similar test procedure to generate data for comparison to the inertia dynamometer test results for validation of the dynamometer test procedure.

This work was performed by the National Traffic Highway Safety Administration, Department of Transportation, since USATACOM did not possess an operational brake dynamometer at that time.

The findings of this test program are presented in their entirety in Bibliography item #10.

A digest of the test is presented below:

A. Test Material

1. Original equipment brake lining designated Code E.

2. Five replacement brake linings designated Codes A, B, C, D and F.

3. All brake linings were 9-7/8 X 2 inch segments, 18-1/4 inch^2 contact area per segment, riveted attachments, 14 rivets per segment.

4. Front and rear duo servo brake assemblies of the M151-A2 identical, except front assembly had 1 inch diameter wheel cylinder and rear assembly had 3/4 inch diameter wheel cylinder.

All tests were performed with new brake linings and drums.

B. Test Equipment

1. Dynamometer. The Inertia Brake Dynamometer used was a dual-end dynamometer, having a brake station at either end of a rotating shaft. However, all tests conducted during this investigation were single-end tests, with front and rear brakes being tested separately. Brake performance test data was continuously recorded on a 24 channel oscillographic chart recorder. Only five data channels were used for these tests; namely, shaft speed, brake torque, brake line pressure, brake drum temperature and brake lining temperature. The dynamometer brake assembly included a vehicle wheel mounted to the brake drum by the mounting lugs to more closely simulate cooling air flow to that of the vehicle brake.

2. Vehicle -- 1/4 ton 4X4 Truck. The M151-A2 was instrumented to measure the following variables to describe braking system performance:

a. Vehicle speed

b. Vehicle deceleration

c. Hydraulic line pressure

d. Temperature of secondary brake linings in each of the four brakes

e. Temperature of the right front and right rear brake drums.

3. Brake Wetting System. In order to run water recovery tests in the lining evaluation tests, it was necessary to build a brake wetting system. A nozzle consisted of 1/4 inch copper tubing brazed to a fitting which was screwed into the backing plate of all of the brake assemblies used for the test. The nozzle extended approximately 1 inch into the brake. A water tank was installed on the M151-A2 to provide water during the vehicle tests.

C. Test Methods and Procedure

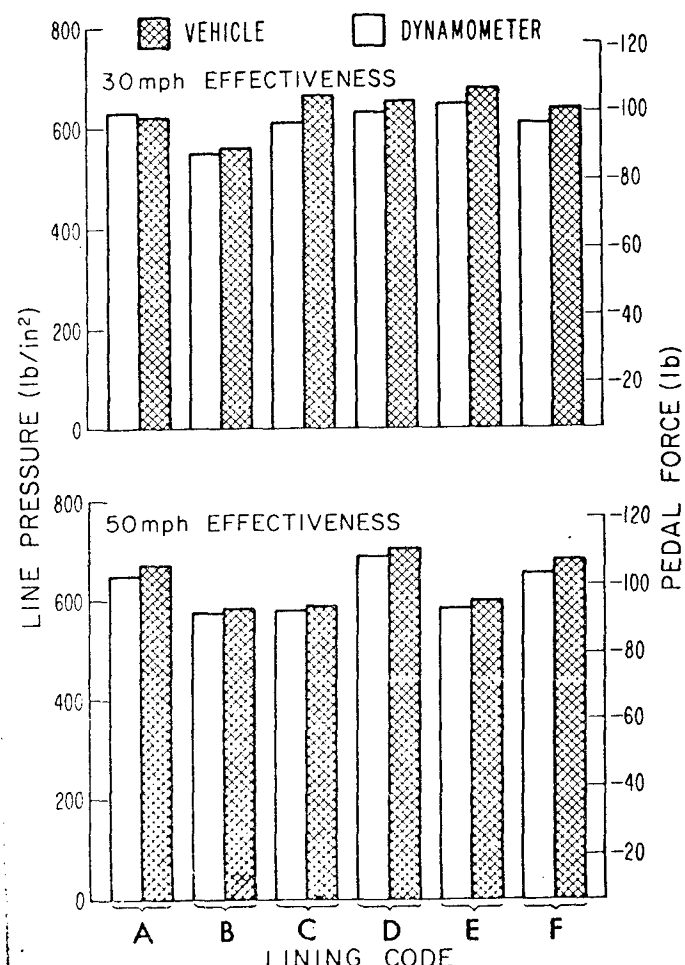
1. Both vehicle and dynamometer tests were conducted in accordance with dynamometer test procedure of the Appendix.

2. Three vehicle tests were performed for the OE lining. One vehicle test was performed for each of the five replacement linings.

3. Three front and three rear dynamometer tests were performed for the OE lining. One front and one rear dynamometer test was performed for each of the five replacement linings.

D. Test Results

The correlation between the dynamometer and the vehicle test results was very close. Most often the difference between the dynamometer and the vehicle data was within the variance that existed for repeated runs on a dynamometer of the same lining formulation. Typical results are tabulated below.



Dynamometer and Vehicle Line Pressure for 20 ft/sec^2 Deceleration - Second Effectiveness Test

DISCUSSION

A. Data Variance

The Safety Systems Laboratory of the National Highway Safety Administration has found from previous testing that the repeatability that can be expected between two or more dynamometer tests, performed on the same machine, are in the order of ± 10%.

B. Effectiveness Test Data

Of the three effectiveness tests performed, Preburnish effectiveness data is the least reliable. This data is greatly influenced by the fit of the drum and lining. This data is also greatly influenced by the variance of drum finish, lining grind, drum diameter and lining radius. The best measure of lining effectiveness are the second and final effectiveness tests. The test results of organic linings, as a rule, will show a sizeable reduction in brake effectiveness between Preburnish and final effectiveness.

C. Fade and Recovery Data

Test results have shown that the maximum disagreement between dynamometer and vehicle data exists for recovery tests. This is most likely the result of differences in maximum temperature reached during the fade test. Even a 30° to 50° F. variation in maximum fade temperature reached, can result in delayed fade which will produce a different recovery curve. Interpretation of dynamometer fade and recovery test results with respect to total vehicle performance is not easily performed. The dynamometer test, as performed here in a single-end mode, assumes constant torque distribution between the front and rear axles. In actual practice this is not the case, since by the 15th fade stop there usually exists a large temperature variation between the front and rear brakes which results in a change in actual torque distribution. Therefore, absolute comparison between vehicle dynamometer data cannot be made in this area. Nevertheless, since the purpose of this test is to rank brake linings for "or equal" performance criteria,

this does not affect the credibility of the test procedure results.

D. Wear

In interpreting wear data it is important to sepatate the wear experienced during the effectiveness and fade and recovery portion of the test from that experienced during the wear portion. A high wear rate during the effectiveness and fade-recovery portion may mean that that lining experiences a high wear rate at high temperatures which are the results of fade tests. Since fade level temperatures are experienced infrequently in actual vehicle operation, acceptance or rejection of brake linings should be based more on the wear test data results. It should be noted that the wear data does not pretend to convert to actual vehicle wear mileage, since this is the result of the in-service use that the vehicle is subjected to. However, the wear data obtained is a valid tool for "or equal" comparison.

E. Water Recovery

In interpreting water recovery test results, it is more important to look at the number of stops to base line rather than the brake pressure during the first two applications.

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APPENDIX A

BRAKE LINING DYNAMOMETER TEST PROCEDURE

1. SCOPE.

1.1. Scope - This test procedure shall be applicable to brake lining materials for automotive use but not for industrial or aeronautical uses. The test methods are designed to determine the performance characteristics of original equipment (OE) brake linings. The performance characteristics that are measured are cold effectiveness, fade and recovery, water recovery, wear rates and physical strength.

2. SAMPLING.

2.1. Samples for test - Samples for test shall consist of two lining and shoe assemblies for drum brakes or two lining and backing plate assemblies for disc brakes.

3. TEST EQUIPMENT.

3.1. Tests shall be performed on a single end, inertia brake dynamometer. If a dual dynamometer is used, it shall be operated in a single end mode.

3.2. The inertia shall be variable in increments of 5 slug feet^2.

3.3. The dynamometer shall have the capability of controlling the brake input line pressure to achieve a constant brake torque output throughout a brake application.

3.4. Means shall be provided for varying brake cooling air velocity.

3.5. Means shall be provided for introducing water onto the brake linings and pads.

3.6. Dynamometer instrumentation -

3.6.1. Hydraulic or pneumatic line pressure, as required, shall be recorded.

3.6.2. Brake torques shall be recorded.

3.6.3. Brake drum temperatures shall be recorded.

3.6.4. Shaft speed shall be recorded.

3.6.5. Means shall be provided for reading out revolutions to stop and time to stop.

3.6.6. Fluid displacement shall be recorded for hydraulic brakes.

3.6.7. The overall system accuracy for all recording and indicating instrumentation shall be ± 2% or better.

4. TEST PREPARATION.

4.1. Brake drums or discs - New drums or discs shall be used for each test. Surface finish, dimensional characteristics (wall thickness variation and runout) shall be within the tolerances specified by ordnance drawings. Material composition and properties shall be in accordance with ordnance drawings.

4.2. Friction material - The linings shall be visually inspected for workmanship and defects. Dimensions and placement of the friction material on the brake shoes and brake pads shall be in accordance with ordnance drawings.

4.3. Thermocouple installation - Either of the methods described in paragraphs 4.3.1. and 4.3.2. may be used for installation thermocouples.

4.3.1. Resistance weld method - Use a resistance welder to attach each wire of the thermocouple to the disc or drum in the locations shown in Figure 1. Two thermocouples are required for a brake disc installation. Disc bulk temperature is the average of the two indicated temperatures.

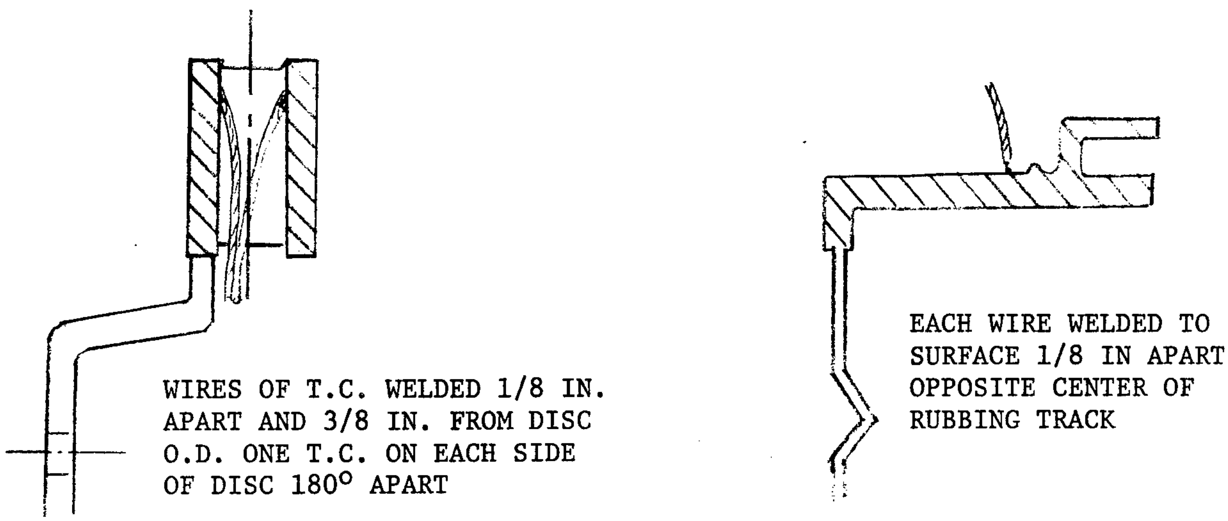


Figure 1

4.3.2. Staking method - Drill holes in the brake disc or drum in the locations shown in Figure 2. Thermocouple wires shall be staked in holes with a center punch.

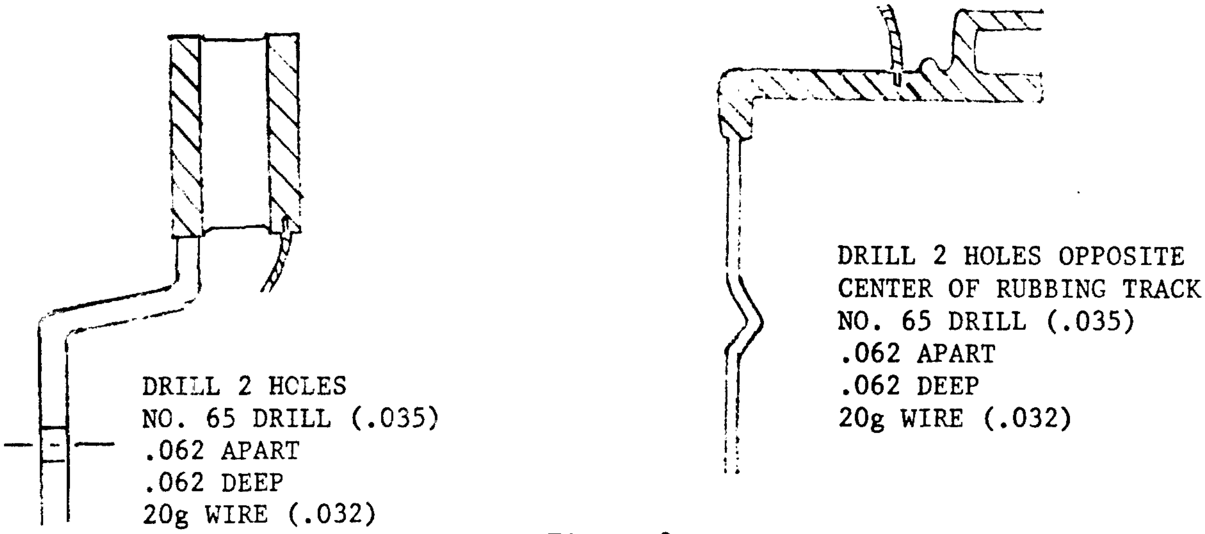


Figure 2

4.3.3. In all installations the wires may be protected against breakage from fatigue by surrounding the junction with high temperature silicone adhesive sealant.

4.4. Brake adjustment - Brake lining clearance shall be adjusted according to vehicle maintenance manual specification.

4.5. Dynamometer flywheel inertia - The total test moment of inertia of the rotating components of the dynamometer shall be calculated as follows:

$$I = \frac{Wr^2KN}{2g}$$

Where: I = moment of inertia, slug ft^2

W = GVW of simulated vehicle, lb

r = tire rolling radius, ft

g = 32.2 ft/$second^2$

N = correction factor for parasitic losses

K = fraction of total braking torque contributed by the brakes on the axle from which the test brake was taken.

NOTE: Test inertia shall be rounded off to the nearest increment of 5.

4.5.1. Calculation of n - The parasitic drag acting on a moving vehicle varies approximately as the square of the vehicle velocity. N shall be calculated by determining the coasting deceleration of the vehicle through vehicle tests.

$$N = \frac{a - n}{a}$$

Where: a = deceleration used for fade test

n = parasitic deceleration due to drag at average test speed

4.5.1.1. Test shall consist of accelerating the vehicle to maximum speed, placing the transmission in neutral and measuring deceleration versus speed until the vehicle reaches a stop. Several repeat runs shall be made in opposite directions and results averaged to cancel the effects of head wind and test site slope. A curve showing the vehicle coasting deceleration with respect to vehicle velocity shall be plotted.

4.5.1.2. Where it is impractical to measure N, a value of 0.9 may be substituted.

4.5.2. Calculation of K - Brake torque distribution must be in the ratio of the wheel cylinder areas.

$$K = \frac{A_1}{A_T}$$

Where: A_1 = wheel cylinder or caliper piston area of brakes on axle from which test brake has been removed.

A_T = wheel cylinder or caliper piston area for all brakes on vehicle.

4.6. Pedal force line pressure relationship - A static calibration shall be made to relate brake line pressure to pedal force. A pedal force transducer shall be attached to the vehicle brake pedal and line pressures shall be recorded for various constant pedal force applications. A

calibration curve shall be plotted on the dynamometer test data sheets.

4.7. Test rpm required to simulate the specified vehicle speeds shall be calculated as follows:

$$rpm = \frac{14.02 \text{ X mph}}{r}$$

Where: r = tire rolling radius

4.7.1. Tire rolling radius shall be determined by counting the number of revolutions of a vehicle tire required to travel a measured distance and then calculated as follows:

$$R = \frac{D}{2\pi N}$$

Where: D = distance traveled

N = number of revolutions

4.8. Test deceleration - All brake stops during the procedure shall maintain a constant brake torque output which results in a constant deceleration. All specified decelerations shall be the rate of change in velocity (slope of velocity/time curve) measured from the time brake reaches the preset torque to the time where the rpm is equivalent to 5 mph. The relationship between deceleration and torque is as follows:

$$T = \frac{W}{g} ar$$

Where: T = total brake torque (lb ft)

W = vehicle test weight (lb)

g = 32.2 ft/second^2

a = deceleration produced by brakes (ft/second^2)

r = tire rolling radius (ft)

4.9. Brake cooling air velocity determination - To correctly simulate vehicle brake duty cycles on an inertia dynamometer it is necessary to adjust the cooling airflow over the dynamometer brake to a

value which will match the cooling airflow of the vehicle.

4.9.1. Instrumentation -

4.9.1.1. Temperature - Drum or disc temperature shall be measured on the vehicle by means of thermocouples installed on all brake drums or discs as specified in paragraph 4.3.

4.9.1.2. Deceleration - Vehicle deceleration shall be measured by means of U-tube decelerometer which shall be mounted on the vehicle windshield in front of the driver. Deceleration value shall be corrected for vehicle tip.

4.9.1.2.1. Vehicle "tip measurement - Pictures shall be taken of vehicle at fade test deceleration to determine tip angle, θ, graphically. True deceleration shall be determined as follows:

$$a_T = a_a - g \text{ SIN } \theta$$

Where: a_T = true deceleration

a_a = apparent deceleration

g = 32.2 ft/sec^2

θ = tip angle

4.9.2. Fade test - Vehicle shall perform fade test under following conditions.

a. Initial brake temperature = 150° before first stop.

b. Stop speed = 50 mph or 5 mph less than vehicle maximum speed. Lower value shall be used.

c. Stops required = 15.

d. Stop interval = minimum required to achieve stop speed.

e. Stop deceleration = 15 ft/sec^2. If vehicle cannot complete 15 stops at 15 ft/sec^2 deceleration shall be lower to a maximum deceleration which will allow vehicle to complete 15 stops without fading.

f. Vehicle weight - rated maximum highway load.

Record maximum temperature reached on all brake drums or brake discs at completion of 15th stop.

4.9.3. Dynamometer cooling air velocity - Test performed in paragraph 4.9.2. shall be repeated on dynamometer using same values for initial brake temperature, stop speed, stop number, stop deceleration and inertia representing vehicle weight. Dynamometer brake air flow shall be manually varied until dynamometer fade tests produce brake drum temperature similar to vehicle brake drum temperature at the 15th fade stop. Cooling air temperature shall be between 70^{o} and $90^{o}F$.

4.10. Test notes -

4.10.1. Initial brake temperature is defined at brake drum or disc temperature at the time of brake application.

4.10.2. If the brake requires warming to a prescribed initial temperature use the burnish procedure with a cycle time of not less than 45 seconds.

4.10.3. Maximum line pressure is the peak value occurring during a stop or if the peak occurs at the end of the stop it is the value of the line pressure observed at an rpm equivalent to 5 mph.

4.10.4. Average line pressure is the average value measured from a point where the brake reaches constant torque and the point at which the rpm is equivalent to 5 mph.

4.10.5. Brake application rate shall be between 1,000 and 2,000 psi/second.

4.11. Brake cooling speed - For all temperature initiated stops, the brake shall rotate at an rpm equivalent to 40 mph.

5. PERFORMANCE TEST.

5.1. First wear measurement - Before mounting brake shoes on dynamometer, measure thickness (lining and shoe) of primary and secondary linings. Use template to locate position of six micrometer readings as shown in Sheet 9 of Appendix A. Use micrometer with ball shaped anvil for all wear measurements.

5.2. Preburnish check - As a general check of instrumentation, brake operation and dynamometer function make 10 stops from 30 mph at 10 ft/second^2 with a 90 second cycle time. If it is necessary to repair,

replace or adjust any brake or dynamometer system component make not more than 10 additional stops. If more than a total of 20 stops are required for instrumentation, brake and dynamometer function check, the brake linings or pads and drums or discs must be replaced.

5.3. Preburnish effectiveness check -

a. Initial brake temperature before each stop = 200°F.

b. Stop speed = 30 mph and 50 mph.

c. At each speed make sufficient constant deceleration stops to cover the range from 5 ft/second^2 to 25 ft/second^2. Do not exceed 100 psi air pressure for pneumatic brakes or maximum hydraulic pressure attainable on vehicle.

5.4. Burnish -

a. Stop speed = 40 mph.

b. Stop deceleration = 12 ft/second^2 for vehicles under 10,000GVW and 10 ft/second^2 for vehicles exceeding 10,000 GVW.

c. Stops required = 200.

d. Stop cycle = as required to maintain an initial brake temperature of 250°F.

5.5. Second effectiveness test - Repeat paragraph 5.3.

5.6. First reburnish - Repeat paragraph 5.4. except 35 stops required.

5.7. First fade and recovery test -

5.7.1. First baseline check -

a. Stop speed = 30 mph.

b. Stop deceleration = 10 ft/second^2.

c. Stops required = 3.

d. Initial brake temperature 150°F. before each stop.

5.7.2. First fade -

a. Stop speed = 50 mph or the same as that used in paragraph 4.9.2., during vehicle test.

b. Stop deceleration = 15 ft/second^2 or the same as that used in paragraph 4.9.2. during vehicle test.

c. Stops required = 15.

d. Initial brake temperature = 150°F. before first stop.

e. Stop interval = 44 seconds or the same as that used in paragraph 4.9.2. during vehicle test.

5.7.3. First recovery - After last fade stop run dynamometer 117 seconds for vehicles under 10,000 GVW and 165 seconds for vehicles exceeding 10,000 pounds GVW, and make first recovery stop.

a. Stop speed = 30 mph.

b. Stop deceleration = 10 ft/second^2.

c. Stops required = 12.

d. Stop interval = 112 seconds for vehicles under 10,000 pounds GVW and 160 seconds for vehicles exceeding 10,000 pounds GVW.

5.8. First effectiveness spotcheck -

a. Stop speed = 50 mph.

b. Stop deceleration = 15 ft/second^2 for vehicles under 10,000 pounds GVW and 12 ft/second^2 for vehicles exceeding 10,000 pounds GVW.

c. Stops required = 2.

d. Initial brake temperature = 200°F. before each stop.

5.9. Second reburnish - Repeat paragraph 5.6.

5.10. Second fade and recovery - Repeat paragraph 5.7.

5.11. Second effectiveness spotcheck - Repeat paragraph 5.8.

5.12 Third reburnish -

Repeat paragraph 5.6.

5.13 Final Effectiveness

Repeat paragraph 5.3

5.14 Fourth reburnish -

Repeat paragraph 5.6

5.15 Wet brake test -

5.15.1 Baseline -

(a) Stop speed = 30 mph.

(b) Stop deceleration = 10 ft/second^2

(c) Stops required = 3

(d) Initial brake temperature = 150°F. before each stop.

5.15.2 Wetting of brakes - with a shaft speed of 72 rpm, open watering valve to brake. Allow water to flow for 5 minutes at a flow rate of approximately 1/2 to 1 gallon per minute. Close valve and stop dynamometer shaft. Detach brake watering tube at the backing plate connection. Fifty (50) seconds after closing water valve, accelerate to test speed.

5.15.3 Water recover - First stop to be performed within 1 minute of closing brake watering valve.

(a) Stop speed - 30 mph

(b) Stop deceleration = 10 ft/second^2.

(c) Stops required = 15

(d) Stop interval = 20 seconds for vehicles under 10,000 lbs. GVW and 30 seconds for vehicles over 10,000 lbs. GVW.

5.15.4 Second wear measurement -

Repeat paragraph 5.1

6.1 Wear test -

6.2 Wear run -

(a) Stop speed = 40 mph

(b) Stop deceleration = 8 ft/second^2 and 12 ft/second^2 in alternate multiples of 25 stops.

(c) Stops required = 1,000 total.

(d) Initial brake drum temperature = 300°F. before each stop

6.3 Final wear measurement - Repeat paragraph 5.1

6.4 Wear data shall be presented as three values:

(a) Wear during performance test, paragraph 5 to 5.15.4

(b) Wear during wear test, paragraph 6 to 6.2

(c) Total wear, paragraphs 5.1 to 6.2.

APPENDIX B

DATA SHEETS

INERTIA BRAKE DYNAMOMETER TEST NO. ________

VEHICLE MODEL ________________
TEST WEIGHT ________ lb = ________ lb FRONT + ________ lb REAR
EFFECTIVE TIRE ROLLING RADIUS ________ in TIRE SIZE ______________
OTHER INFORMATION ____

BRAKE SIZE ________________ TYPE ________________ CYL. DIA. ________ in.
LINING CODE ____________________ METHOD OF ATTACHMENT __________________
OTHER INFORMATION ____

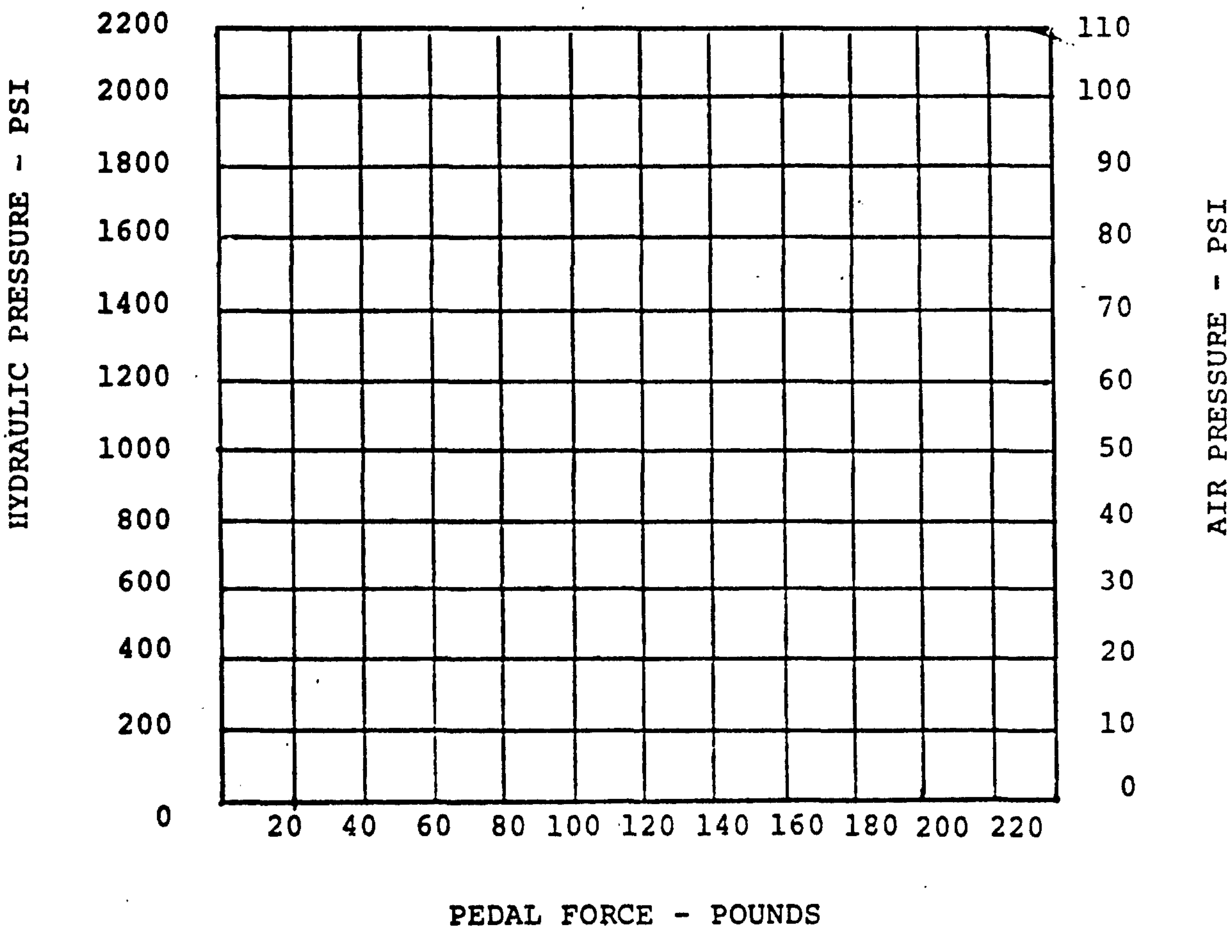
DYNAMOMETER FLYWHEEL INERTIA ________ slugs ft^2
BRAKE COOLING AIR VELOCITY ________ mph
OTHER INFORMATION ____

ABBREVIATIONS:

DECEL=DECELERATION (ft/sec^2)
LP=LINE PRESSURE (lb/in^2)
IBT=INITIAL BRAKE TEMPERATURE
TRQ=BRAKE TORQUE (lb/ft)

DT=DRUM TEMPERATURE (°F)
UNLESS STATED LINE PRESSURE & TORQUE READINGS ARE AVERAGE VALUES

LINE PRESSURE/PEDAL FORCE RELATIONSHIP



MPH - RPM RELATIONSHIP ____ IN ROLLING RADIUS	
MPH	RPM
10	
20	
30	
40	
50	
60	

Pre-Burnish Check 30-0 mph, 10 ft/sec^2 ____ second intervals		
STOP	LP	TRQ
1		
2		
3		
4		
5		
6		
7		
8		
9		
10		

PRE-BURNISH EFFECTIVENESS 200°F. lb + each STOP			30 MPH	
	LINE PRESSURE		TRQ	TIME-SEC
DECEL	MAX.	AVG.	AVG.	TO STOP

Burnish 40-0 MPH, ft/sec^2, 250°F., IBT each STOP					
STOP	LP	TRQ	STOP	LP	TRQ
1			120		
20			140		
40			160		
60			180		
80			200		
100					

SECOND EFFECTIVENESS 200° IBT EACH STOP				
	LINE PRESSURE		TRQ	TIME-SEC
DECEL	MAX.	AVG.	AVG.	TO STOP

FIRST REBURNISH
40-0 MPH ft/sec^2
250°F., IBT EACH STOP

STOP	LP	TRQ
1		
10		
25		
35		

FIRST BASELINE CHECK
30-0 MPH 12 ft/sec^2
150°F., IBT EACH STOP

STOP	LP	TRQ
1		
2		
3		

FIRST FADE
____-0 MPH ____ ft/sec^2 ______ sec int
150°F. IBT First Stop Cooling Air Temp ______ °F.

STOP	DT		TRQ	LP	
	INITIAL	MAX	AVG	MAX	AVG
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

FIRST RECOVERY
____-0 MPH ____ ft/sec^2 First Stop ____ sec after
Last Fade Stop, Other Stops ____ sec interval.

STOP	DT		TRQ	LP	
	INITIAL	MAX	AVG	MAX	AVG
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					

First Effectiveness Spotcheck 50-0 MPH, 15 ft/sec^2 200°F. IBT each Stop		
STOP	LP	TRQ
1		
2		

Second Reburnish 40-0 MPH ft/sec^2 250°F. IBT each Stop		
STOP	LP	TRQ
1		
10		
25		
35		

FIRST FADE:

Fluid Dispersion
Stop 1 ____ in^3
Stop 15 ____ in^3
Diff.__________

Second Baseline Check 30-0 MPH 10 ft/sec^2 150°F. IBT each Stop		
STOP	LP	TRQ
1		
2		
3		

SECOND FADE:

Fluid Dispersion
Stop 1 ____ in^3
Stop 15 ____ in^3
Diff.__________

Second Fade _____-0 MPH ___ ft/sec^2 _____ second interval 150°F. IBT first Stop Cooling Air Temperature _____ °F.					
	DT		TRQ	LP	
STOP	INITIAL	MAX	AVG	MAX	AVG
1					
2					
3					
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
14					
15					

SECOND RECOVERY

____-0 MPH ____ ft/sec^2 First Stop ____ sec after 1st Fade, Other Stops ____ sec interval.

Second Affectiveness Spotcheck

____-0 MPH 15 ft/sec^2

200°F. IBT each Stop

STOP	LP	TRQ
1		
2		

Third Reburnish

40-0 MPH ft/sec^2

250°F. IBT each Stop

STOP	LP	TRQ
1		
10		
25		
35		

FINAL EFFECTIVENESS 200°F. IBT each Stop 30 MPH				
	LINE PRESSURE		TORQUE	TIME-SEC
DECEL	MAX	AVG	AVG	TO STOP

FOURTH REBURNISH 40-0 MPH ____ ft/sec^2 250°F. IBT each Stop		
STOP	LP	TRQ
1		
10		
25		
35		

WET BRAKE BASELINE

30-0 MPH $10\ ft/sec^2$

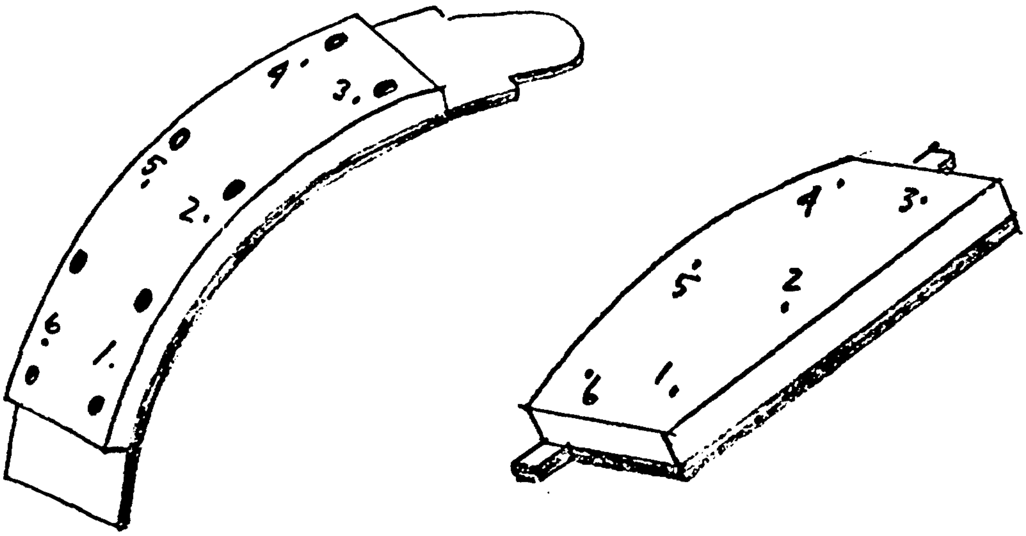
$150^{o}F.$ IBT each Stop

WET BRAKE RECOVERY

30-0 MPH $10\ ft/sec^2$

_____ second interval between Stops

STOP	LINE PRESSURE		TRQ
	MAX	AVG	AVG
1			
2			
3			
4			
5			
6			
7			
8			
9			
10			
11			
12			
13			
14			
15			



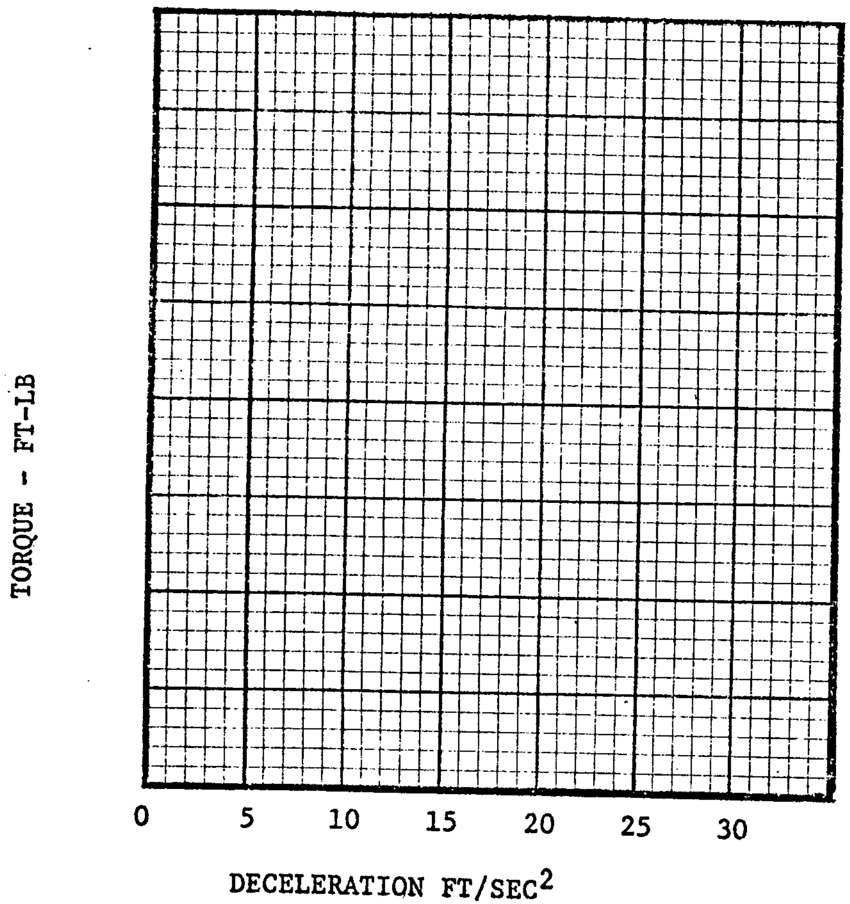
PRIMARY SHOE OR RIGHT PAD						
WEAR MEASUREMENT	LINING & SHOE/PAD THICKNESS					
	1	2	3	4	5	6
FIRST						
SECOND						
THIRD						
TOTAL						
SECONDARY SHOE OR LEFT PAD						
FIRST						
SECOND						
THIRD						
TOTAL						

AVERAGE TOTAL WEAR:

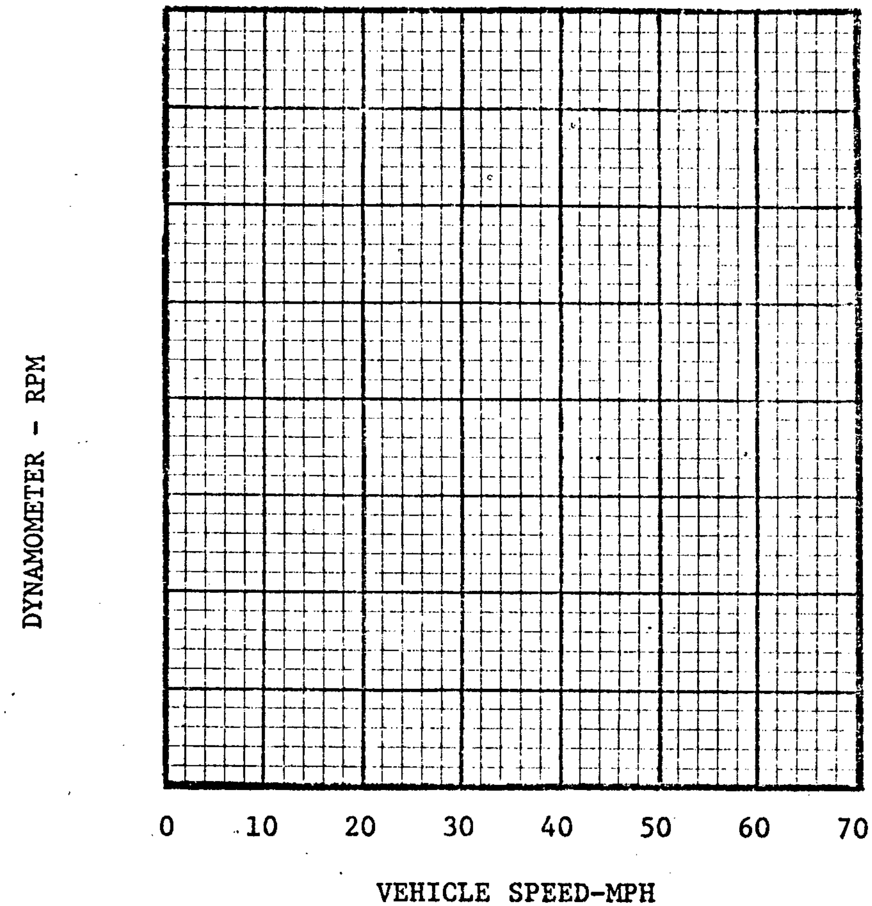
Primary Shoe/Right Pad = _____ in.

Secondary Shoe/Left Pad = _____ in.

TORQUE - DECELERATION RELATIONSHIP

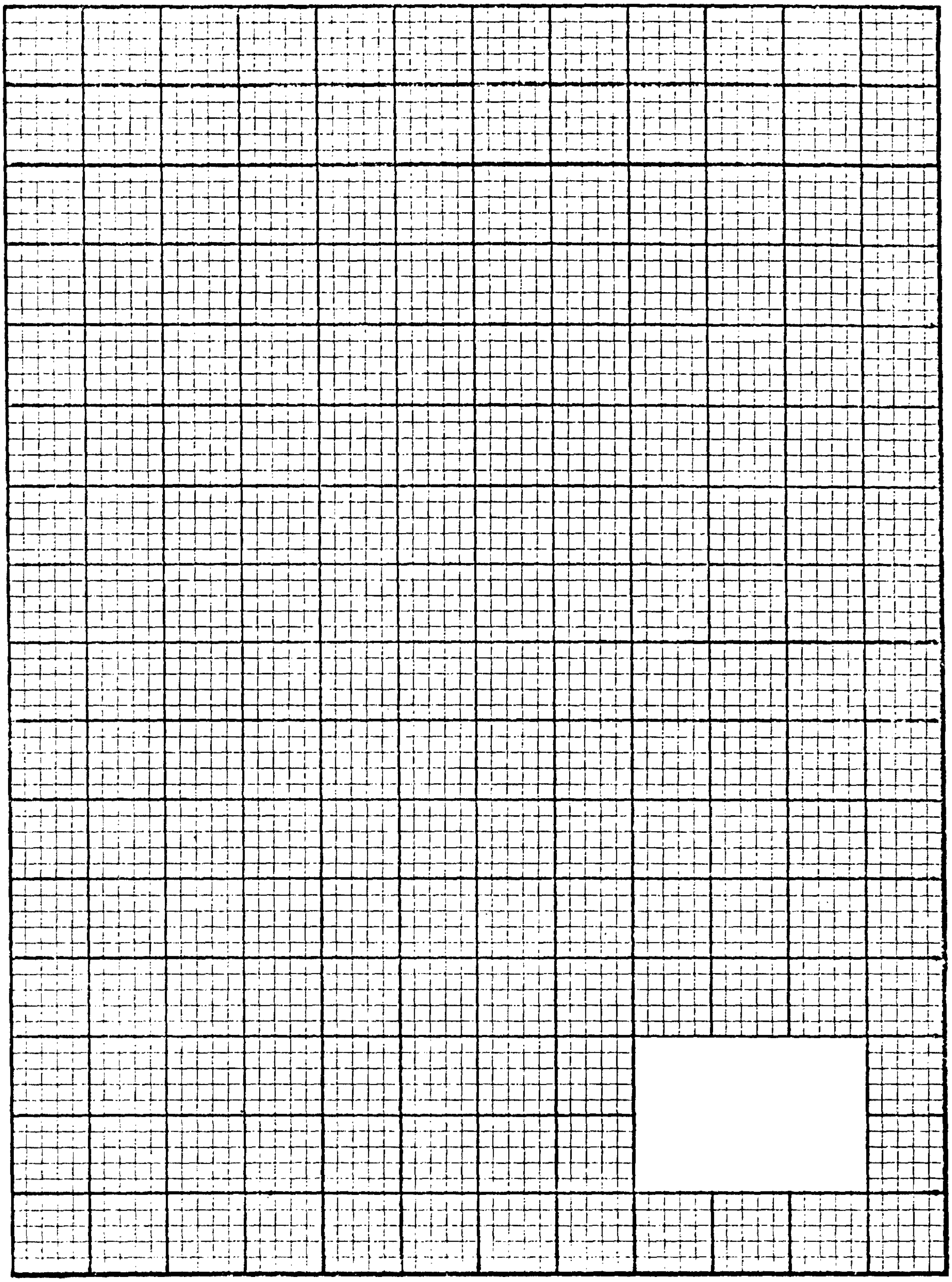


VEHICLE MPH - DYNAMOMETER RPM RELATIONSHIP



PREBURNISH EFFECTIVENESS TEST

BRAKE TORQUE (lbs/ft)



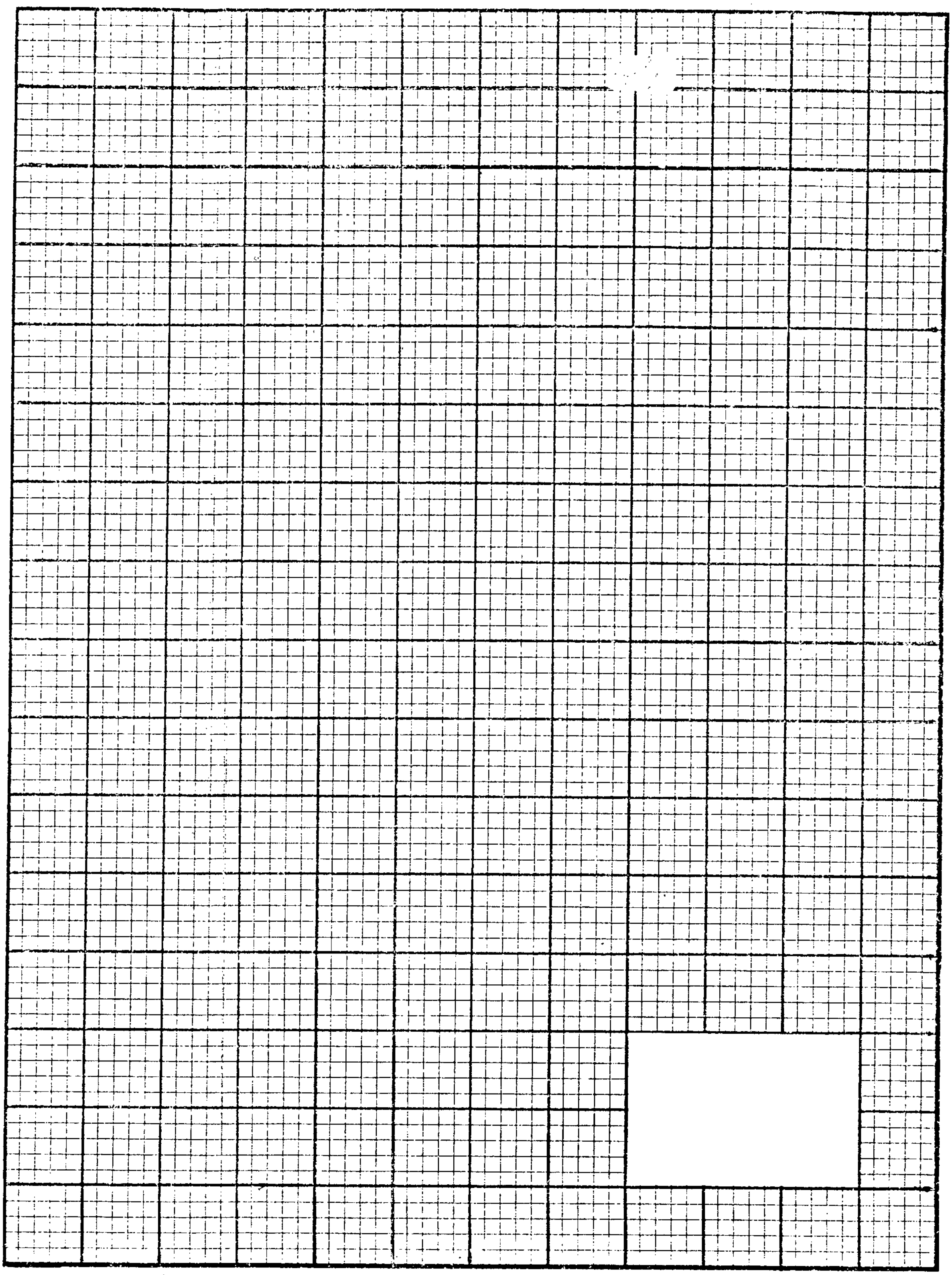
LINE PRESSURE PSI

LINING CODE

TEST NO. ________

SECOND EFFECTIVENESS TEST

BRAKE TORQUE (lbs/ft)

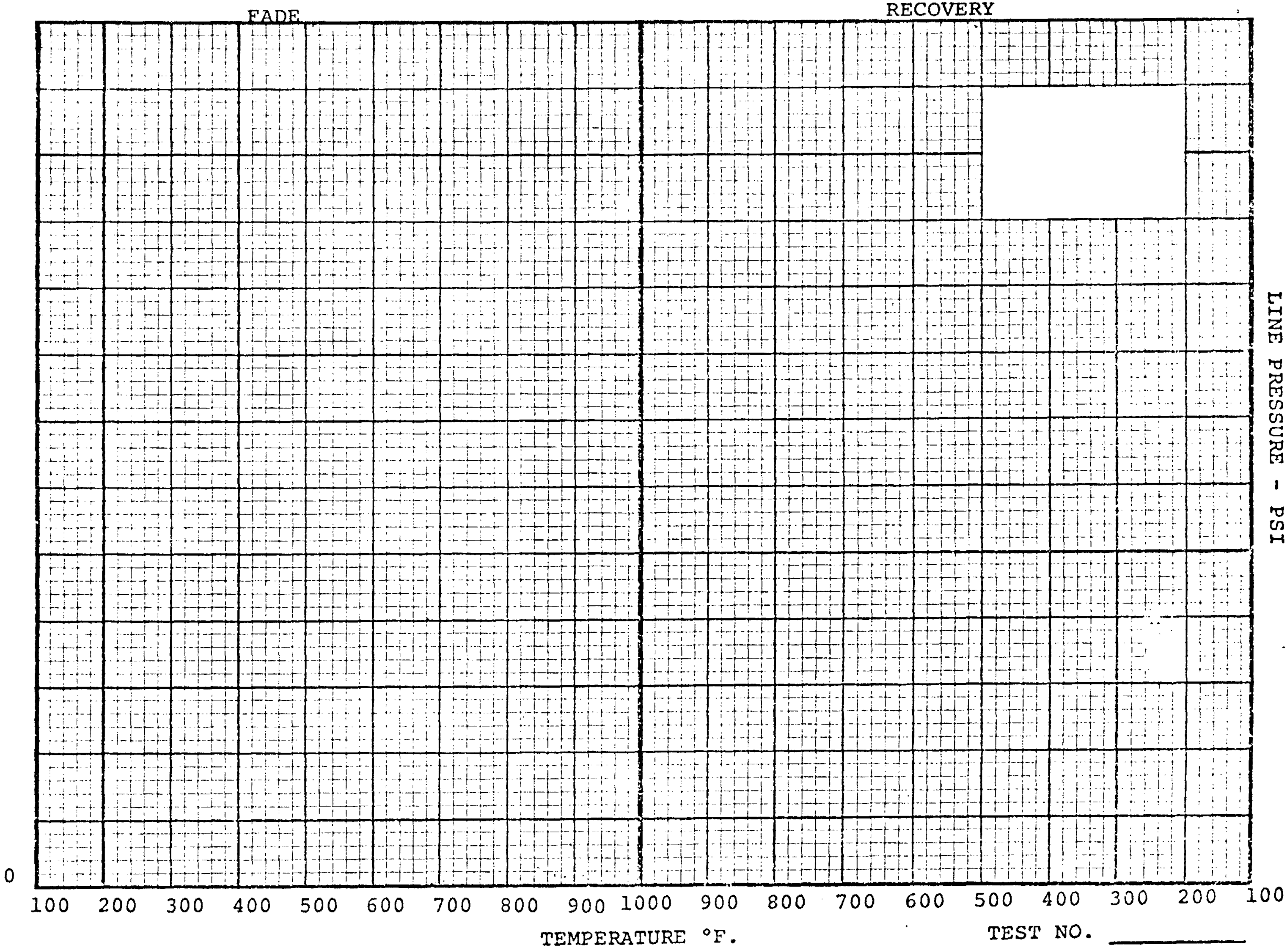


LINE PRESSURE PSI

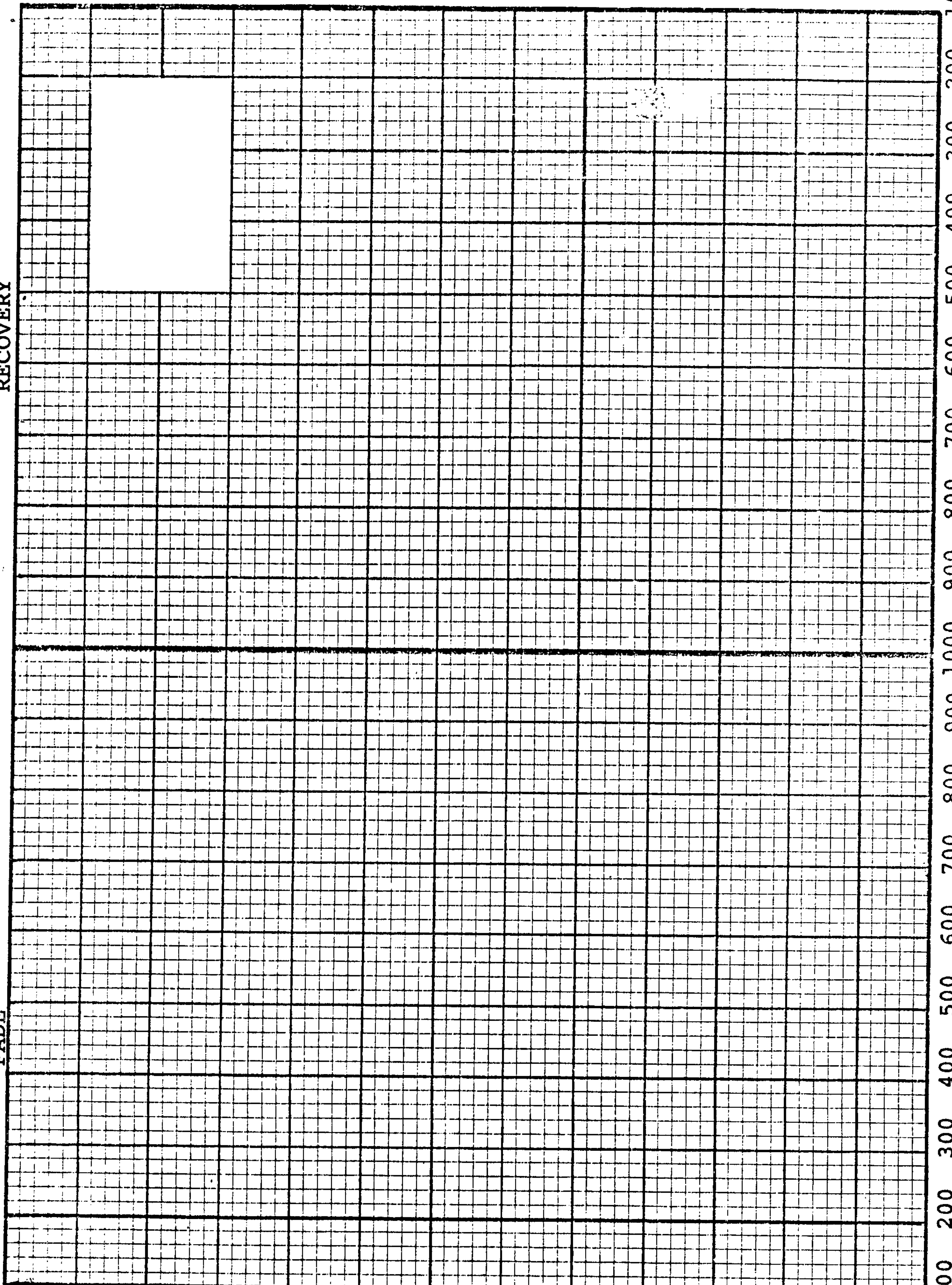
LINING CODE

TEST NO. ________

FIRST FADE-RECOVERY TEST

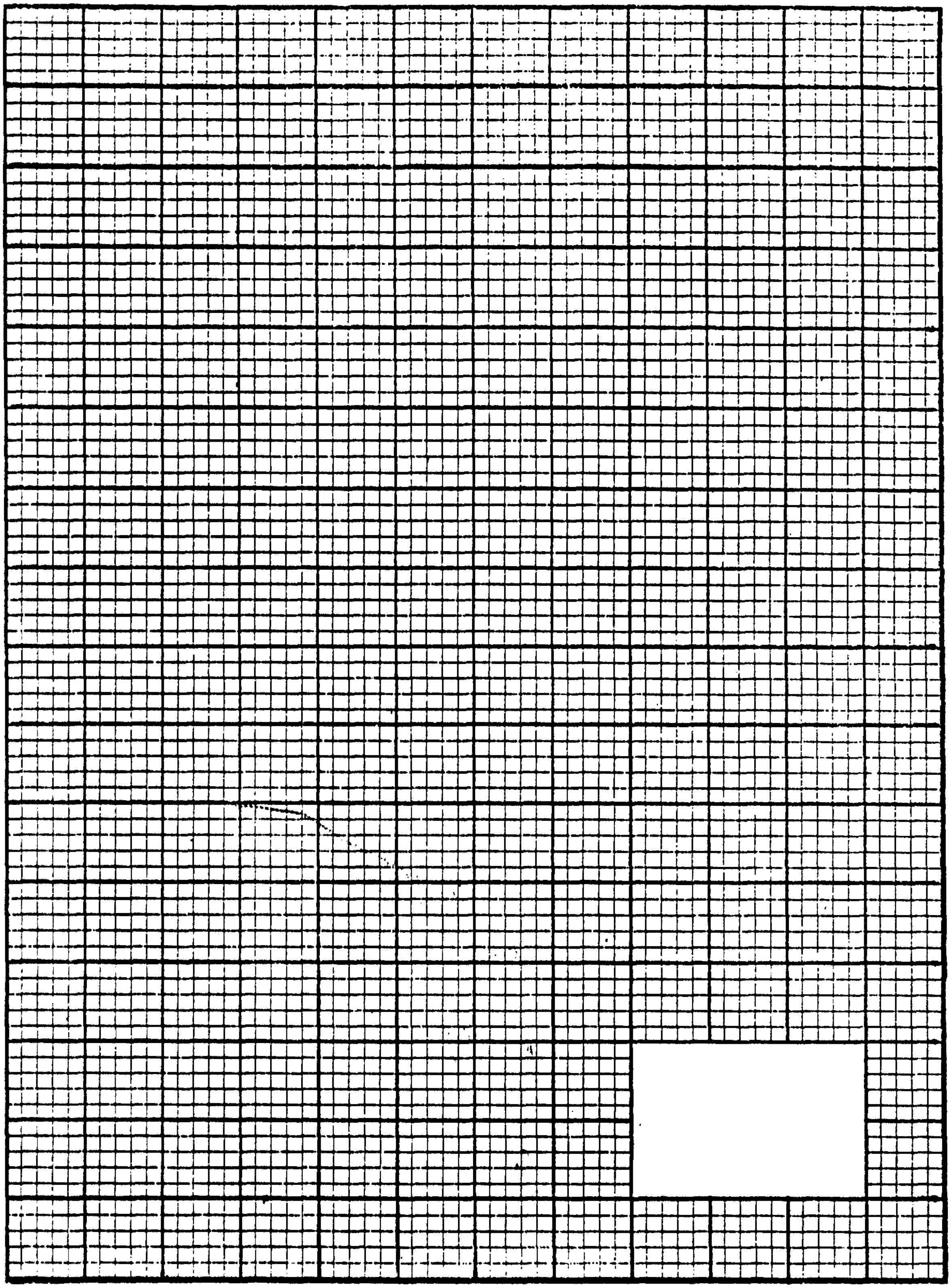


LINE PRESSURE - PSI



FINAL EFFECTIVENESS TEST

BRAKE TORQUE (lbs/ft)



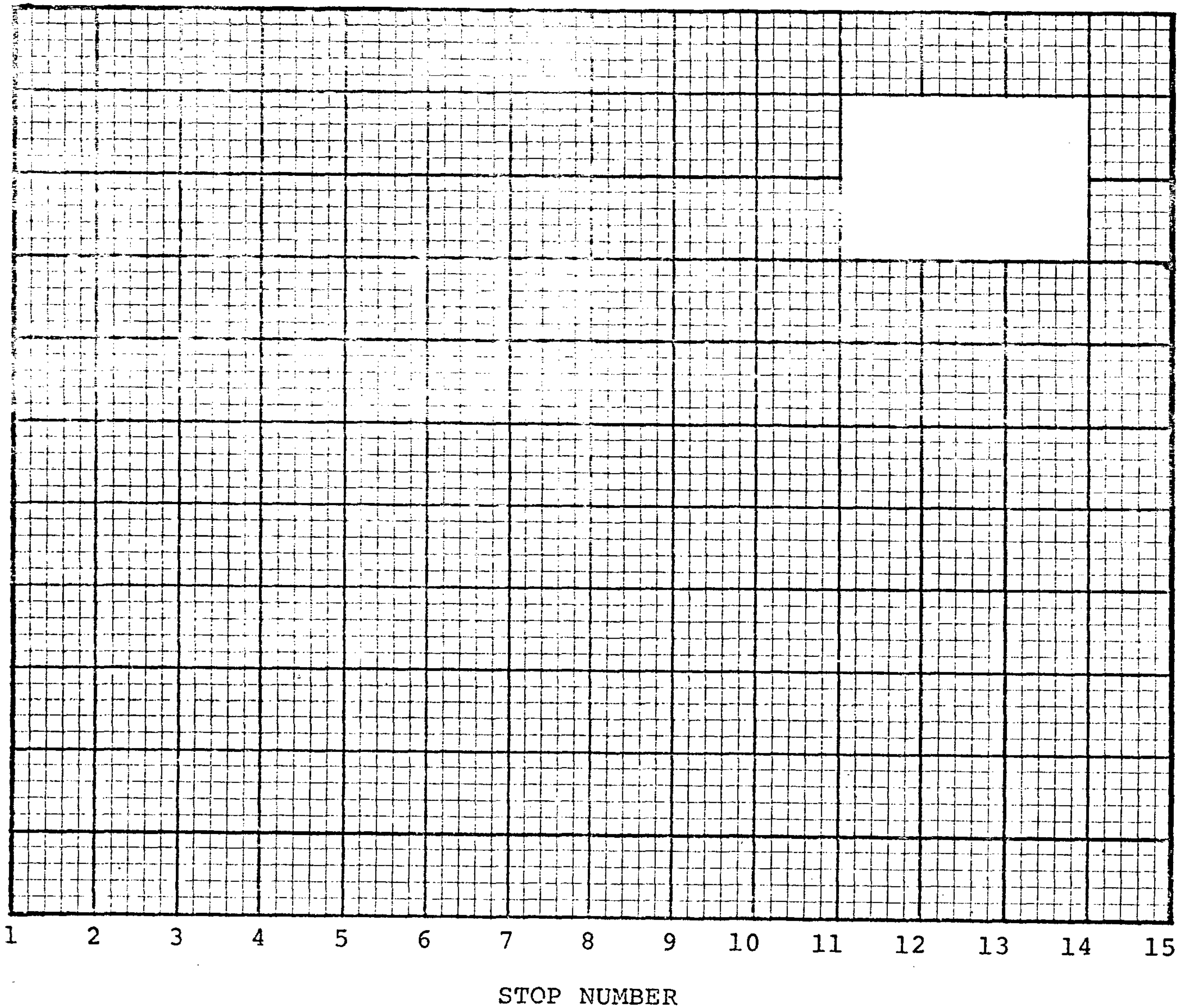
LINE PRESSURE PSI

LINING CODE

TEST NO. ________

TEST NO. ______

WATER RECOVERY TEST



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13. ABSTRACT

This is a report of an effort to develop a laboratory test procedure for measuring the performance of a brake assembly and individual components on a brake dynamometer. This report presents a test procedure that measures brake retarding torque versus temperature, brake retarding torque versus speed, brake lining wear rate and moisture sensitivity.

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